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# Warehouse Location Decision Factors in Humanitarian Relief Logistics

Sae-yeon ROH\* · Hyun-mi JANG\*\* · Chul-hwan HAN\*\*\*

## Contents

I . Introduction	IV. Results of Analyses
II . Literature Review	V. Conclusion
III. Methodology	

## Abstract

The importance of preparedness is emphasised as humanitarian supply chain gets even more sophisticated. Among the different forms of preparedness for disaster relief management, pre-purchasing of stock in a pre-positioned warehouse is considered to be best for maximising the effectiveness of humanitarian aid supply chains. However, there have been very few studies that consider the business-focused application of the multi-criteria location problem to the pre-positioning of warehouses for humanitarian relief organizations. Therefore, this study empirically identifies the key factors considered for selecting humanitarian relief warehouse location as criteria in AHP. Results indicate that the cooperation attribute is the most important factor when selecting facility location in humanitarian relief, followed by national stability, cost, logistics and location. Theoretical and managerial implications of the research findings for humanitarian relief logistics are discussed.

**Key Words :** Humanitarian Relief Logistics, Warehouse Location, Pre-positioning, AHP

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## **I. Introduction**

Recently, an increasing number of humanitarian relief organizations have begun to locate strategic pre-positioned warehouses around the world to save and assist disaster victims as soon as possible by delivering sufficient relief aid effectively within a short time.<sup>1)</sup> In the relief chain, decisions on facility location and stock pre-positioning are significant for a rapid disaster preparedness and response. Although the importance of selecting a strategic pre-positioning facility was emphasized in business studies, less attention has been given in the domain of humanitarian relief logistics. Thus, the main objective of this study is to suggest the critical factors considered for locating humanitarian relief warehouse. In particular, this study utilizes Analytical Hierarchy Process to determine the important weights of evaluation criteria. This is because warehouse location is regarded as a Multi-Criteria Decision Making (MCDM) problem with uncertainty, subjectivity and ambiguity while a variety of criteria need to be considered.<sup>2)</sup>

The rest of paper is organized as follows: In the next section, literature review on humanitarian relief logistics will be discussed. In section III, methodology focusing on how to select sample, measures and research method is described and the results of analyses are presented in section IV. Conclusions drawn from the analyses and strategic implications are discussed in the final section.

## **II. Literature Review**

### **1. Humanitarian Relief Logistics : Overview and Background**

#### **1) Unique Characteristics of Humanitarian Relief Logistics**

The distinctive characteristics of the disaster relief environment and comparison and contrast between commercial supply chains and humanitarian relief chains were emphasized by Thomas and Kopczak.<sup>3)</sup> Table 1 developed by Tzeng *et al.*<sup>4)</sup> clearly shows the different characteristics of general and

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1) Balcik and Beamon(2008), p.102.

2) Dagdeviren et al.(2009), p.8144.

3) Thomas and Kopczak(2005).

4) Tzeng et al.(2007), p.675.

relief distribution systems. The main goal of operational logistical activities in most humanitarian relief logistics-related studies is to optimize the flow of supplies with their distribution networks. There are three separate parts in relief distribution systems like general physical distribution systems: the supply points which are the collection points of commodities in non-devastated areas, the demand points which are the devastated areas where victims who play the role of customers in general distribution systems exist and also transportation. In particular, large-scale commodities distribution depots near the devastated areas can be said as temporary distribution centers.<sup>5)</sup> Similar to business logistics, humanitarian logistics includes diverse activities such as preparedness, planning, design, procurement, transportation, inventory, warehousing, tracking and tracing, distribution, recipient satisfaction, bidding and reverse bidding, reporting and accountability and customs clearance.<sup>6)</sup> However, the lack of customer pressure makes it more difficult for humanitarian organizations to achieve their goals.<sup>7)</sup>

<Table 1> Comparison of general and relief distribution systems

Comparison Items	General distribution systems	Relief distribution systems
System objectives	Maximize profit	Fairness and efficiency
Dimensional role	Factories Distribution centers Customers	Collection points for commodities Transfer depots for commodities Demand points of commodities
Facility characteristics	Regular facilities Substantial/tangible existence	Temporary facilities
Scheduling plan	Long term: location Median-term: vehicle-fleet size Short-term: scheduling	Urgent decisions based on available information
Trade-offs between algorithm-efficiency and optimization	Paying attention to optimization	Emphasis of algorithm efficiency
Delivery models	Round-trip delivery; circulating delivery	Round-trip delivery

Source: Tzeng *et al.* (2007)

Due to these significant differences of humanitarian logistics from business logistics, the well-established concepts of supply chain literatures, that is, leanness and agility could be hardly applied in this field. Rather, the stocks

5) Balcik and Beamon(2008), p.103.

6) Gustavsson(2003) ; Thomas and Kopczak(2005), p.2.

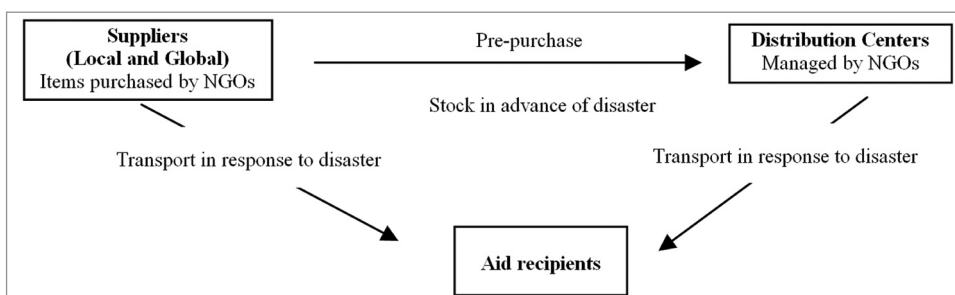
7) Tomasini and Van Wassenhove(2009).

are placed at the donor's desired destination.<sup>8)</sup> However, together with these good supply chain practices, the idea of the virtual warehouse (VM) by means of advanced technologies and real-time decision algorithms addressed by Landers *et al.*<sup>9)</sup> would be useful in humanitarian logistics to improved operating efficiencies and global inventory visibility.

## 2) Procurement of Supplies in Humanitarian Relief Supply Chain

Figure 1 demonstrates how humanitarian organizations procure relief goods once a disaster occurs. The relief organizations can obtain relief supplies from their own centralized warehouse or local suppliers first and if not, they make an effort to acquire items from global suppliers through competitive bidding process. Long-term and strong relationships with their suppliers are highlighted for most commonly wanted goods in nature disasters.<sup>10)</sup>

<Figure 1> Overview of relief supply chain



Source: Balcik and Beamon (2008)

Otherwise, they are being pre-purchased and stocked at distribution centers (i.e. pre-positioned stocks) in advance and then distributed directly to aid recipients.<sup>11)</sup> Pre-purchasing of the supplies has the advantage of reasonable price when the demand for supplies is low before a disaster takes place.<sup>12)</sup> The location of distribution centers is selected in accordance with their strategic operations to be able to carry out the pre-disaster activities rapidly.<sup>13)</sup>

8) Oloruntoba and Gray(2006), p.118.

9) Landers et al.(2000), p.115.

10) Kovacs and Spens(2007), p.102.

11) Balcik and Beamon(2008), p.107.

12) Salisbury(2007), p.108.

13) Beamon and Balcik(2008), p.106.

## **2. Pre-Positioning in Humanitarian Relief Logistics**

### **1) Humanitarian Relief Pre-Positioning Facility Location Problems**

In addition to the capacities of the resource providers, the location is revealed to play a major role to achieve a high-performance disaster response after an event. However, there has been little research conducted on facility location problem regarding both theory and applications in humanitarian relief logistics. It is also notable that a large number studies have mainly focused on the finding of potential optimal location with optimization models rather than to find the important attributes for the location of the pre-positioned warehouse in humanitarian relief sectors.

For instance, by using the reliability of the ground transportation network, Ukkusuri and Yushimoto<sup>14)</sup> proposed a model on location routing problem and pre-positioning supplies. Hale and Moberg<sup>15)</sup> suggested the optimal secure locations which can balance cost-efficiency and operational effectiveness on the basis of their analysis on the minimum number and possible location of off-site storage facilities. From these, nonetheless, it is difficult to identify the crucial attributes that play key roles when deciding the appropriate locations for pre-positioned stocks as well as establish preferences between factors by reference to an explicit set of objectives.

### **2) Warehouse Location Decision Criteria**

The attributes used for warehouse selection used in AHP varies from case-to-case such as by country or by industry type. For the warehouse selection problem, Alberto<sup>16)</sup> grouped into 7 main criteria of environmental aspects, cost, quality of living, local incentives, time reliability provided to customers, response flexibility to customer's demands, and integration with customers in Italy. Demirel *et al.*<sup>17)</sup> used cost, labor characteristics, infrastructure, markets and macro environment for their study of warehouse selection in Turkey. Korpela and Tuominen<sup>18)</sup> considered the reliability, flexibility, and strategic compatibility for their main criteria. Ozcan *et al.*<sup>19)</sup> used only main criteria that consist of unit price, stock holding capacity, average distance to shops,

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14) Ukkusuri and Yushimoto(2008), p.2.

15) Hale and Moberg(2005), p.195.

16) Alberto(2000), p.279.

17) Demirel et al.(2010), p.3945.

18) Korpela and Tuominen(1996), p.175.

19) Ozcan et al.(2011), p.9776.

average distance to main suppliers, and movement flexibility.

In short, previous studies supported that warehouse location selection can be approached from both macro perspectives by Hoover<sup>20)</sup> and micro perspective by Freese.<sup>21)</sup> Schmenner<sup>22)</sup> also indicates that the major locational determinants can be used with regional and specific site determinants. Additionally, it was found that the sub-criteria of the attributes fit into different main criteria. It is also complicated to decide which criteria are significant as they are all assessed differently according to their research characteristics by decision-makers. The inconsistent grouping of the criteria depends on how the researcher looks into the problem and determined the hierarchy structure of the attributes. Most importantly, it is crucial to consider the unique characteristics of humanitarian relief logistics itself to develop a sophisticated location decision structure.

### **III. Methodology**

The principal goal and rationale of this research are inspired by the need to identify major attributes to locate humanitarian relief warehouse which can provide improvements to the problematic situations that may stem from them. To achieve this goal, the current study utilized mixed methods, which combine quantitative and qualitative methods, with more emphasis on the quantitative method. In other words, semi-structured interviews with practitioners were first employed at an exploratory stage to help classify the attributes and then questionnaires for AHP were followed. As there is inconsistency in selecting and grouping critical attributes applied for warehouse, distribution/logistics center, and general facility selection in previous literatures, the exploratory study was first decided to conduct with experts to get feedback on the attributes. This combination is expected to be advantageous in that it allows triangulation to take place.

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20) Hoover(1948).

21) Freese(1994).

22) Schmenner(1982).

## **1. Sample and Measures**

Among different sampling techniques, purposive sampling and snowball sampling were deemed to be the best way to acquire data for this interview. Purposive sampling allows the researchers to use their judgment to select cases based on the knowledge and experience of a researcher. In snowball sampling, the researcher contacts a small number of people initially and then uses these to establish contacts with other people.<sup>23)</sup> A total of 25 participated in the semi-structured interviews. The interviews were conducted in almost every region around the world because of the unique characteristics of the warehouse location scattered around the world. They were conducted in Africa (Sudan, Uganda, and Zimbabwe), America (Canada, Panama, and United States of America), Asia (China, Iraq, Korea, Nepal, Philippines, and UAE), and Europe (Norway and United Kingdom) over two months. They were asked to participate in the interview either by face-to-face, email or telephone.

Most of the participants replied through the email where they were based in remote country from the researcher when they were not able to spare a time for telephone interview. During the interviews, other potential interviewees were suggested by the initial participants. Even though the characteristics of organizations varies whether they are NGOs, international organizations or government support organizations, they are all posted in the managerial level of their organization that have influence in decision making process. This demonstrates that they have sufficient knowledge of this industry. Eight of them were interviewed by the face-to-face method, one was interviewed on the telephone and 16 of them were via email due to the physical remoteness.

Altogether 29 different attributes as determining factors for humanitarian relief pre-positioning warehouse were drawn from the respondents. They were as follows: Proximity to disaster prone areas; Logistics experts availability; Warehouse security; Geographical location; Transport connectivity; Availability of seaport and airport; Near to (potential) beneficiaries; Adequate warehouse facilities; Adequate warehouse infrastructure; Warehouse accessibility; Storage cost; Stable government; Trained and qualified personnel; Flexible customs regulations; Proximity to urban facilities;

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23) Saunders et al.(2007).



Warehouse capacity; Labor availability; Logistics service; IT/Communication; Cost relate to logistics; Land cost; Climate; Replenishment cost; Donor's opinion; Labor price; Existence of other agents (NGOs); Cooperation with logistics agents; Closeness to other warehouses; Political and economical stability.

To add/eliminate attributes and establish the hierarchical structure between attributes, group working members were formed within the logistics offices of the organizations. Finally, 25 attributes were chosen and 11 members from the international organization participated in this study to select the critical pre-positioned warehouse location factors. Table 2 illustrates the decision hierarchical structure for pre-positioning warehouse location attributes used in this research.

## **2. Research Method**

The Analytical Hierarchy Process (AHP) method was selected to determine the relative importance of a set of attributes for humanitarian warehouse location. The AHP process makes it possible to incorporate judgments on intangible qualitative criteria alongside tangible quantitative criteria.<sup>24)</sup> The AHP method based on three principles, that is, 1) structure of the model, 2) comparative judgment of the alternatives and the criteria; and 3) the synthesis of the priorities<sup>25)</sup> has been widely used in multi-criteria decision-making problems. Although AHP has been used in various location decision-making problems,<sup>26)</sup> it has not received much attention in the field of humanitarian logistics. Accordingly, this method deems to be appropriate for this research.

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24) Badri(1999), p.240.

25) Amiri(2010), p.6219.

26) Torfi et al.(2010), p.520.

<Table 2> Description of the criteria for regional warehouse location

Main criteria	Sub-criteria	Description of criteria
Location	Geographical location	The physical geographical location of the warehouse
	Proximity to beneficiaries	The proximity and accessibility to the beneficiaries
	Disaster free location	The safe area not easily affected by disasters (natural/man-made)
	Donor's opinion	The opinion of donors on the locations importance
	Climate	The impact of climate on the area
	Closeness to other warehouses	The geographical distance to other regional/local warehouses
	Proximity to disaster prone area	The geographical distance to frequent disaster occurrence area
Logistics	Airport	Considering the capacity to handle large aircraft, air national carriers connections, availability of air cargo companies, and operational ability
	Seaport	Considering accessibility to seaport, frequency of shipping services, quality of the seaport, handling capacity, and distance from the warehouse
	Road	Road infrastructure considering the trucking service, countries connected and road conditions
	Warehouse	Warehouse infrastructure considering the facility, security, capacity and proximity to urban facilities
National Stability	Political stability	Stable political decisions or political change
	Social stability	Risk of riots or protest towards the government
	Economical stability	Important level of output growth and low and stable inflation
Cost	Labor	Labor cost
	Land	Cost of land
	Storage	Maintenance cost of storage
	Replenishment	Impact of change in replenishment cost due to competitive prices, productivity, and access of relief items
	Logistics	Logistics cost from the warehouse to the aid recipients and within the country
Cooperation	Host government	Accessibility of the nation's and military assets, financial aid and incentives
	Int'l NGOs	Cooperation in information, facilities, and personnel sharing, etc in the country
	Local NGOs	
	UN	
	Neighbor countries	Aid support of the neighbor countries in relief items, facilities, etc
	Logistics agents	Logistics training and lease of logistics facilities

## IV. Results of Analyses

In this section, the results of analyses on the preference order of the major attributes as well as sub-attributes of each main factor will be illustrated. Firstly, Table 3 presents the consistency checking results of the attributes obtained for selecting warehouse location of the humanitarian relief logistics. Based on the consistency checking obtained in this table, the entire consistency ratio (CR) of the pairwise matrix for all attributes is calculated less than 0.1. The weights are shown to be consistent and they are acceptable to be used in the selection process.<sup>27)</sup>

<Table 3> Consistency of the obtained results

Attributes	$\lambda_{\max}$	CI	RI	CR
Major	5.3948	0.0987	1.12	0.0881
Location	7.2358	0.0393	1.32	0.0298
National stability	3.1032	0.0516	0.58	0.0890
Cost	5.0864	0.0216	1.12	0.0193
Cooperation	6.2325	0.0465	1.24	0.0375
Logistics	4.0681	0.0227	0.90	0.0252

### 1. Major Attributes

Table 4 presents the preference order of importance of the major attributes. The Cooperation attribute turned out to be the most important factor for the consideration of the warehouse location selection with a normalized weight of 0.2908. National stability attribute follows with a normalized weight of 0.2282 to be the next important attribute. The first two attributes consist of an accumulated weight of 0.5190 (51.90%) which is more than a half of the whole percentage. The third important attribute is Cost attribute with a normalized weight of 0.2270. The accumulated weight rises up to 0.7460 (74.60%) when this attribute is added to the first two. Logistics attribute ranked in fourth from the table with a normalized weight of 0.1525. The last attribute that considered being the least important is Location attribute with a normalized weight of 0.1015. In short, the table explains that the decision-makers consider the Cooperation attribute to be most essential among the

<sup>27)</sup> Dagdeviren et al.(2009), p.8144.

major attributes for humanitarian warehouse location selection. On the other hand, Location attribute is considered least important in this study.

<Table 4> The preference order of the major attributes

Rank	Criteria	Normalized Weight	Accumulated Weight
1	Cooperation	0.2908	0.2908
2	National stability	0.2282	0.5190
3	Cost	0.2270	0.7460
4	Logistics	0.1525	0.8985
5	Location	0.1015	1.0000
Total Weight		1.0000	

## 2. Sub-Attributes

Following tables confirm the overall result of the preference order of importance for each sub-attribute. First, according to Table 5 on *Location*, Proximity to disaster prone areas is considered to be the most important attribute with a normalized weight of 0.2275. Disaster free location follows with a normalized weight of 0.1826. Donor's opinion ranked in third in the table with a normalized weight of 0.1604. The first three of the attributes consist of an accumulated weight of 0.5891 (58.91%) among the attributes. The last two attributes, considered to be less important in warehouse selection, are Geographical location and Climate with a normalized weight of 0.0864 and 0.0447 respectively.

<Table 5> The preference order of *Location* attributes

Rank	Criteria	Normalized Weight	Accumulated Weight
1	Proximity to disaster prone areas	0.2275	0.2275
2	Disaster free location	0.1826	0.4101
3	Donor's opinion	0.1790	0.5891
4	Proximity to beneficiaries	0.1604	0.7495
5	Closeness to other warehouses	0.1194	0.8689
6	Geographical location	0.0864	0.9553
7	Climate	0.0447	1.0000
Total Weight		1.0000	

From Table 5, it can be concluded that Proximity to disaster prone areas is considered to be most imperative for warehouse selection, but Climate is not

as important as other factors.

According to Table 6 on *National Stability*, Political stability is considered being the most vital attribute with a normalized weight of 0.4934, almost half of the total percentage. The Economical stability follows next with a normalized weight of 0.3108. These two attributes consist of an accumulated weight of 0.8042 (80.42%) of the total weight. The least important attribute is Social stability with a normalized weight of 0.1958. It is very likely that the future of the organization is to be affected by the political issue of the country than other attributes. It is easier for the organization to prepare and operate in the country if the political issues can be predicted and well read.

<Table 6> The preference order of *National Stability* attributes

Rank	Criteria	Normalized Weight	Accumulated Weight
1	Political	0.4934	0.4934
2	Economical	0.3108	0.8042
3	Social	0.1958	1.0000
Total Weight		1.0000	

According to Table 7 regarding *Cost*, Logistics is considered to be most essential with a normalized weight of 0.3281. Cost relating to Replenish follows next with a normalized weight of 0.2164. These two attributes consist an accumulated weight of 0.5445 (54.45%) of the total weights.

<Table 7> The preference order of *Cost* attributes

Rank	Criteria	Normalized Weight	Accumulated Weight
1	Logistics	0.3281	0.3281
2	Replenish	0.2164	0.5445
3	Storage	0.1884	0.7329
4	Labor	0.1428	0.8757
5	Land	0.1243	1.0000
Total Weight		1.0000	

On the bottom of the table, Land is considered to be the least important of all with a normalized weight of 0.1243. The cost related to logistics is an important attribute because the office they stand is provided free of charge and it will be the logistics cost to cut down that they need to focus. In other words, Cost of the land is not an important concern for the international

humanitarian relief organizations because land is offered free of charge from the government most of the times.

Next, according to Table 8 regarding *Cooperation*, Host government considered being the most important attribute for warehouse selection with a normalized weight of 0.3678. United Nations follows next with a normalized weight of 0.2442. The first two attributes consists of an accumulated weight of 0.6120 (61.20%) of total weight. The cooperation of the host government is very important because they are the body that deals with land, warehouse, customs regulations and bills, etc.

<Table 8> The preference order of *Cooperation* attributes

Rank	Criteria	Normalized Weight	Accumulated Weight
1	Host government	0.3678	0.3678
2	United Nations	0.2442	0.6120
3	Logistics agents	0.1620	0.7740
4	Neighbor countries	0.0804	0.8544
5	International NGOs	0.0764	0.9308
6	Local NGOs	0.0692	1.0000
Total Weight		1.0000	

In addition, United Nation agencies are also important as they are one of the largest humanitarian organizations that deal with many relief projects, especially in emergency response. Existence of the United Nations and their cooperation in a country will help the organization to set up a relief supply chain efficiently. International NGOs and Local NGOs list in the bottom two with a normalized weight of 0.0764 and 0.0692 respectively. Here, Local NGOs is selected to be least vital. The weight differences among the last three attributes are very little and they are also considered being less important as compared to the top three. Accordingly they will hardly have any effect on the warehouse selection process.

Finally, the availability of Seaport in the country is revealed to be the most important attribute with a normalized weight of 0.3465 for *Logistics* attributes as seen in Table 9. It does not only indicate that the availability of the seaport is very critical but also the seaport should have the adequate capacity to handle large amount of relief items, frequent shipping service to the demanding area, and facilities for quality storage and handling time. Airport

follows next with a normalized weight of 0.2463. The importance weight of these two attributes consists of an accumulated weight of 0.5928 (59.28%) of total weights. Road and Warehouse attributes have the same normalized weight of 0.2036 forming the bottom in the table. Road is not a big issue for warehouse selection because items are delivered from suppliers by sea-leg and to the beneficiaries by air. In other words, road network to other countries is rarely used in pre-positioning warehouse countries.

<Table 9> The preference order for *Logistics* attributes

Rank	Criteria	Normalized Weight	Accumulated Weight
1	Seaport	0.3465	0.3465
2	Airport	0.2463	0.5928
3	Road	0.2036	0.7964
	Warehouse	0.2036	1.0000
Total Weight		1.0000	

### 3. Final Weights

The final weights of all the individual attributes were calculated to observe the ranking of the preference (Table 10). Political is considered to be the most significant attribute among the sub-attributes with a final weight of 0.1126. The first seven attributes consist of an accumulated weight of 0.5380 (53.80%) which has a big influence on the warehouse location selection decision-making process. In those seven attributes, Political and Economical are from National Stability, Logistics and Replenish are from Cost, Host government and United Nations are from Cooperation, and Seaport is from Logistics attributes. Notably, none of attributes from Location factor are in the position of influencing the decision-making process. Instead, they are found from the bottom of the table regarded as the least key attributes compared to others.

<Table 10> The overall result of the final weights of the sub-attributes

Rank	Attributes	Final weights	Accumulated weights
1	Political	0.1126	0.1126
2	Host government	0.1070	0.2196
3	Logistics	0.0744	0.2940
4	United Nations	0.0710	0.3650
	Economical	0.0710	0.4360
6	Seaport	0.0528	0.4888
7	Replenish	0.0492	0.5380
8	Logistics agents	0.0472	0.5852
9	Social	0.0446	0.6298
10	Storage	0.0428	0.6726
11	Airport	0.0376	0.7102
12	Labor	0.0324	0.7426
13	Warehouse	0.0310	0.7736
	Road	0.0310	0.8046
15	Land	0.0282	0.8328
16	Neighbor countries	0.0234	0.8562
17	Proximity to disaster prone areas	0.0230	0.8792
18	International NGOs	0.0222	0.9014
19	Local NGOs	0.0202	0.9216
20	Disaster free location	0.0186	0.9402
21	Donor's opinion	0.0182	0.9584
22	Proximity to beneficiaries	0.0162	0.9746
23	Closeness to other warehouses	0.0122	0.9868
24	Geographical	0.0088	0.9956
25	Climate	0.0044	1.0000
Total weight		1.0000	

## V. Conclusion

From the empirical analyses of this research, several contributions can be drawn as follows: First, from a theoretical perspective, this study used the Multi-Criteria Decision Making (MCDM) method to discover the



crucial criteria for locating warehouse which has been relatively ignored in humanitarian logistics as compared to in commercial logistics. Rather, a significant body of literature only focused on optimal pre-positioned warehouse locations for humanitarian relief logistics. The results of this empirical research, which is one of the first to identify warehouse location decision factors in humanitarian relief logistics, can be utilized as a stepping stone for further research in this field. Secondly, this research proposed a systematic decision hierarchical structure verified by interviews with international organizations' experts in this field.

Thirdly, from a practical point of view, the understanding of the preference order of major attributes may provide some implications on how humanitarian relief organizations can adjust warehouse location selection process. In particular, the results may be of value to current and potential humanitarian relief organizations in South Korea considering their own warehouse. This is because Korean government efforts to double its international development aid to about \$3 billion by 2015 to give back after receiving help from the international community. Finally, there is an opportunity for knowledge learning between humanitarian organizations and commercial sectors. It has been observed that the humanitarian relief supply chain tends to be more donor driven, while commercial sectors have extensively developed in profit driven.

Nonetheless, some supplements of this study are needed due to the generalizability issue in this study arising from the data collected from limited sample within a limited time frame. Further research can be incorporated into this study with different hierarchical and detailed objectives with sub-factors. Other mathematical models (i.e. TOPSIS) can be combined to obtain final ranking. Also, other organizations in different countries can be selected as a sample for a comparative study. Pre-positioned warehouse selection should be approached cautiously, since humanitarian organizations prefer different attributes from one another or misunderstanding the need of the pre-positioned warehouse might give negative impact on the humanitarian pre-positioned warehouse selection problem, and consequently the relief supply chain as a whole.\*

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